Estimating snow depth of alpine snowpack via multifrequency passive microwave airborne observations: Colorado, USA

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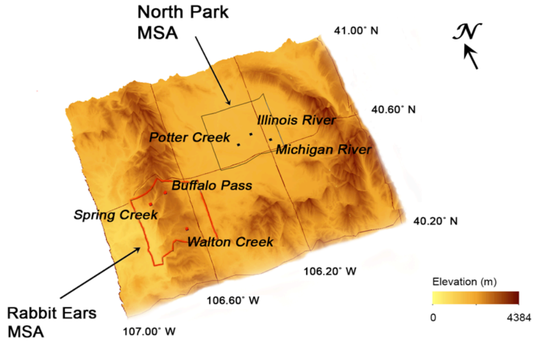
1. Objective

- Seasonal snow cover plays a key role in the climate system. Passive microwave observations are available daily for three+ decades, but a coarse resolution. Much work has been done to develop retrieval algorithms.
- Using model-based estimation frameworks has emerged as a strategy to best use microwave measurements.
- In this study, we estimate snow depth in Colorado, USA by using multifrequency passive microwave airborne observations using a particle filer.

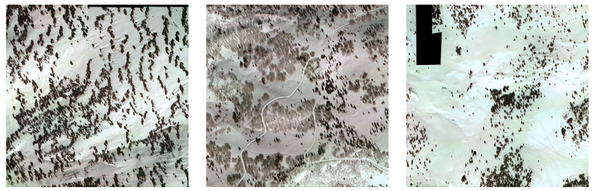
2. Hypotheses

- Single day airborne PM measurement could estimate snow depth correctly.
- Crocus could improve the accuracy of the prediction of snow state.
- A combination of multifrequency radiance has snow information and could help to estimate accurate snow depth.
- Particle filter approach outperforms the Kalman-based filter approach.

3. Study area and Data



- The Cold Land Processes Experiment 2002-2003 and three Intensive Study Areas in the Rabbit Ears Meso-cell Study Area.
- Microwave data : Brightness temperatures (Tb) from Multiband Polarimetric Scanning Radiometer (PSR).
- National Land Cover Database 2001(NLCD 2001) was used for calculating vegetation fraction.
- Ground observation: from snow depth transect data.
- Orthoimagery for each ISAs



Buffalo Pass | Spring Creek | Walton Creek

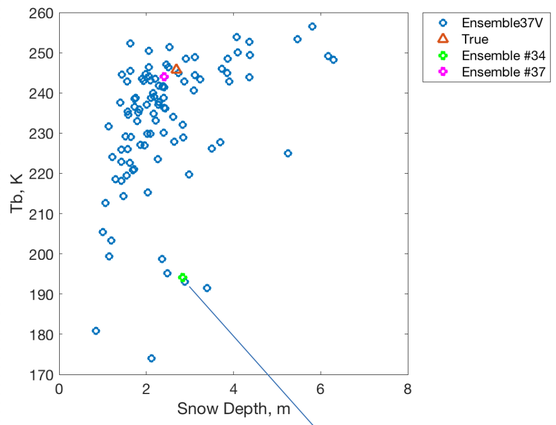
4. Models and retrieval procedures

- Forcing data disaggregation model: to downscale all the forcing data to 120 m resolution (UCLA/Baldo & Margulis).
- Snowpack physical model: Crocus (CNRS/Dumont & Morin).
- Radiative transfer model: Microwave Emission Model of Layered Snowpack.

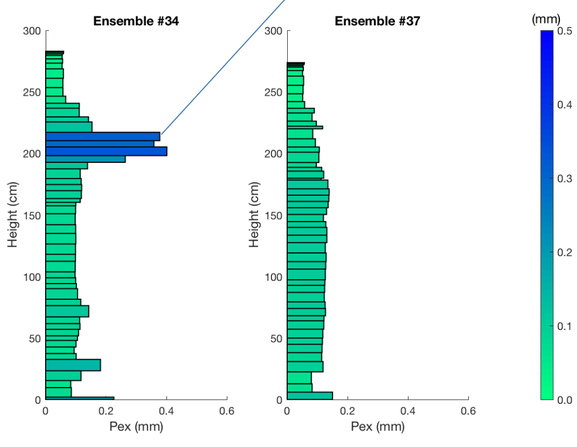
1. The forcing disaggregation model downscales the NLDAS-2 data to model resolution (120 m).
2. The snowpack evolution model (Crocus) prognoses snowpack structure from downscaled forcing data.
3. The radiative transfer model (MEMLS) simulates T_b from Crocus outputs.
4. The particle filter updates the predicted snow depth using observed T_b.
5. Estimated snow depths are validated with snow depth transects measurements.

5. Results

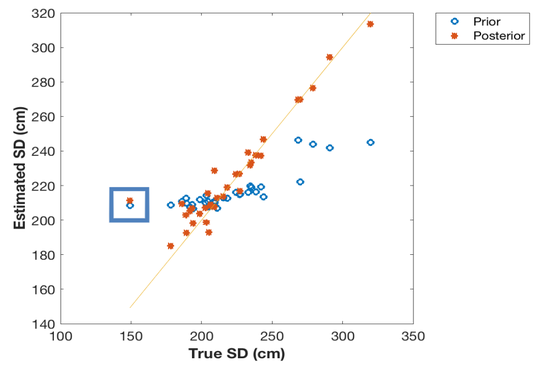
- Crocus: Simulates the physical snowpack processes and layering (stratigraphy) using up to 50 layers, capability to resolve melt-refreeze crusts.
- Microwave-depth relationships revealed by joint snowpack + microwave radiance simulations.
- Note that depths are far past typical values considered for “saturation”, and Tb vs depth correlation is positive, but the there is still some information in the airborne microwave measurements.
- Particle filter: proper to handle non-Gaussian PDFs and non-linear models.



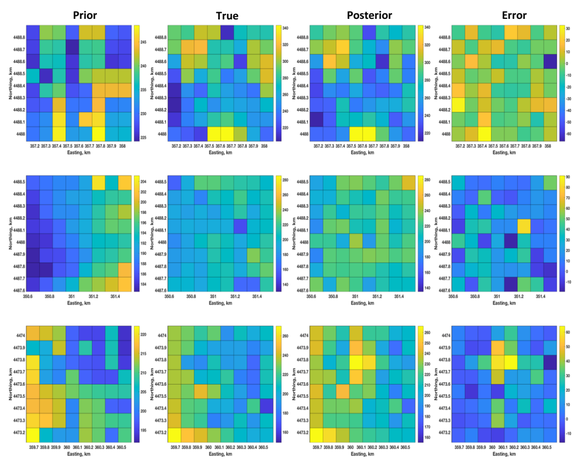
- Possible melt-refreeze due to potential early – season warm temperature lower Tb
- The linear estimator such as Ensemble Kalman Filter are less effective than Particle filter when non-linear relationships are present



	Prior	19+37+89 GHz	10+19+37+89 GHz
R2	0.44 (0.45)	0.81	0.85 (0.94)
RMSE (cm)	25.26 (23.81)	14.78	13.30 (8.10)
Bias (cm)	-4.42 (-6.35)	7.99	4.45 (2.71)



- Particle filter estimates capture snow depth retrieval spatial Patterns constrained by airborne T_b.



6. Conclusions

- Deployed Crocus-MEMLS coupled model with particle filter method.
- 10.7+18.7+37.0+89.0 GHz combination most accurately estimated the snow depths.
- Crocus and particle filter outperform SSib3 and EnKF, respectively.

Acknowledgements

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